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The link to this publication is **https://ajoeer.org.ng/otn/ajoeer/2022/qtr-1/06.pdf**

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ISSN: 2635-2974

MONITORING OIL SPILL REMEDIATION USING GEOGRAPHIC INFORMATION SYSTEM: CASE STUDY OF THE OGONI CLEAN-UP IN RIVERS STATE, NIGERIA.

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ABSTRACT

This research was carried out based on the need for creating a digitalized environmental resource database for Ogoni (comprising its four Local Government Area of Eleme, Khana, Tai and Gokana in Rivers State, Nigeria). Leveraging on the Engaged techniques in monitoring oil spill Remediation management. The research was proposed towards monitoring Remediation with various degrees of impact resulting from oil spill contamination within the study area, through the knowledge of spill sources, contaminated area, degree of impact and sizes, from which a viable database is built. List of the impacted 64 UNEP facts sheets sites, list of 12 sites undergoing Remedial work, spill investigation area and their reference GPS coordinates as provided by HYPREP was analysed using the Geographical Information Systems. collected dataset was analysed using ArcGIS 10.5 as imported in Geographical Information Systems environment, suffer was used in producing maps and contour. Indications from result shows that each impacted site, has an associated source with the contour showing point of high and low impact of contamination. The research has therefore conclusively shown the effective use of Geographical Information Systems, in creating a spatial database in monitoring and modelling oil spill trend for the purpose Remediation putting in place adequate Remediation Management System in the study area. I recommend that Remediation Management System maps covering study area be consistently made available and accessed when needed for upward review.

Key worlds: Oil Spill, Remediation, Environmental Pollution, Ogoni clean-up.

1.1 INTRODUCTION

In Nigeria, oil spillage remains as old as, operations of the petroleum industry. Which has birthed series of argument amongst citizen of either been a curse or blessing. Especially among the indigenes of the Niger Delta region (Ogoni's as a case study). Nigeria listed among the most prolific in oil production amongst the countries of the world with oil and gas serving as its major source of foreign exchange earnings. The activities of the petroleum industry ranging from exploration, production, refining, distribution, marketing and shipping of the oil and gas produced has contributed to the various environmental challenges facing the oil producing area. e.g. the Ogoni's.

1.2 REMEDIATION

The hazard of a polluted environment caused by spill requires immediate remedial action so as to restore the system back it original state. The impact of oil spillage is seen on soil, ground and surface water, plan, and animal resulting from the contaminant present in spill hydrocarbon. The need for a reduction in the concentration of Total Petroleum Hydrocarbon (TPH) level, make remediation necessary. Over the years series of remedial actions has been taken on contaminated system both onshore and offshore, with some degree of success recorded. This calls for upward review of the processes in improving Remediation Management System (RMS) to obtain some level of efficiency in areas of remediation. During remediation several techniques are used depending on the nature of contamination and the contaminated media. Some techniques include, soil vapour extraction, degradation, bioremediation for soil, physical, chemical and thermal.

1.3 SPILL REMEDIATION MONITORING

Continuous spill of hydrocarbon makes the need for an automated monitoring system a necessity for an early detection of spills or possible spill occurrence in both onshore and offshore for analyses. This analysis is used in making contingency plan in the area of spill source, cause of spill, spill volume response, clean-up and remediation. the proposed monitoring system are of three subsystems. Starting from remote sensing, the use of automatic monitoring stations network with contact detectors and combined sensor system based on (remote and contact technologies).

1.2 Geographical information systems in environmental study

In environmental study like monitoring oil spill remediation trajectory, Geographical Information Systems is important in providing needed mechanism to speed up decision making and improves contingency plan with data system content. Geographical Information Systems is used as support tool for improving remediation management system, substantiating methodology of data structuring and analysis. Environmental challenges of pollution and contamination can be mapped and visualized through the use of advanced modelling and visualization features of Geographical Information Systems, proven to be excellent management tool for the assessment of resources, contamination, remediation, oil spill response. Geographic Information System (GIS) is an emerging technology which has been employ in oil spill monitoring, providing mechanism for speedy decision making, contingency and planning from a given dataset in achieving an overlay trajectory model output for decisions like: response strategies, identifying features, prioritising sensitivities for protection, size of contamination, depth of contamination, impact and remediation pathways.

1.4 Geographical Information Systems as A Database Management System

For the repository of large geographic and attribute data, Geographical Information Systems is used as a database management system, which serves the purpose of complementary structure on managing the environment.

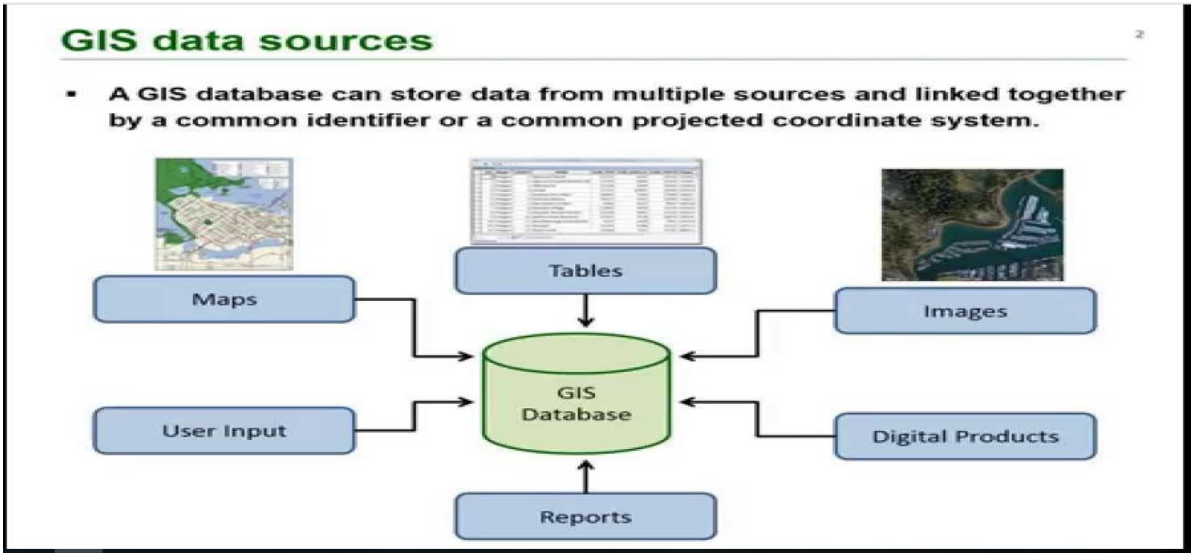

Fig 1.1: Geographical Information Systems data management system

1. 5 STATEMENT OF THE PROBLEM

The effect of indequate remediation techniques used for remedial work on oil impacted area, in achieving sustainable environment and the restoration of ecosystem. Remedial work carried out by SPDC as recommended by UNEP on contaminated layers of soil within the study area (OGONI) was proven ineffective, based on the remediation technique used as the only observed method.This method: Remediation by Enhanced Natural Attenuation (RENA) was deploy on certain assumptions;

a).Specific Oil Nature

b).Temperature and Underlying layer of clay

c).Assumping Hydrocarbon cannot Move in Deeper

UNEP has shown that contamination of the soil can often penetrate deeper than 5m,contaminating groundwater in many location,making previous assumptions not sustainable.this makes the Remediation Management System (RMS) necessary as a single remediation /clean up technique cannot be effective ,knowing the range and degree of impact of oil contamination within the study area(OGONI).

1.6 AIM AND OBJECTIVES OF THE STUDY

This research is aimed at show -casing the effectiveness of Geographic Information System (GIS) technology in monitoring oil spill remediation using the remediation of impacted sites by HYPREP in Ogoni as the case study.

The objectives of this study are:

I. Evaluating the UNEP fact sheet of impacted sites in Ogoni, and develop a conceptual model of remediation action plan, incorporating these data into the Geographical Information Systems evironment.
II. To identify basic factors effective in remediation management system, through analysing data and information, utilising Geographical Information Systems to determine the spatial distribution of oil contamination impact as well remediation pathway.
III. To create online maps for both impacted sites and site undergoing remedial action to be viewed for decision making.

2. 0 LITERATURE REVIEW

2.1 Remediation.

Several studies ranging over 300 have been made in areas of oil spill and remediation in the Niger Delta, from academic, government and the industry, emphasising on the economic impact (Stone *et al,*2013) In most studies the impact of oil spill both social-economic and environmental has been extensively dealt with. Taking into consideration various approaches in the study of oil spillage, which has yielded positive result in the area of environmental consciousness both to the Petroleum industry and the people. Significant literature prominent in this study including; the 1978 Amoco *C*adiz *oil spill offshore of Brittany*, France; the 1989 Exxon V*aldez oil spill in Prince William Sound*, Soil Pollution and Remediation (J Paz-Ferreiro; 2018). Impact of oil spill On Marine Life (IMK Saadoun;2015) This has also reduced the incident over the years through various mechanism from engineering design to expertise.

Table 2.1: Recent oil spill in the world (www.ijrise.org|editor@ijrise.org)

Year	Location	Country	Oil spill (Tonnes)
19 May 2015	California coast	USA	330
13 April 2015	English Bay	Canada	2.3
5 March 2015	Near Galena	USA	Unknown
17 January 2015	Glendive	USA	41-160
6 December 2014	Trans-Israel pipeline	Israel	1948-4300

Table 2.2: Biggest oil spill in the world (www.ijrise.org|editor@ijrise.org)

Year	Location	Country	Oil spill (million gallon) approx.
1991	Gulf of Kuwait	Kuwait	240 -336
1979	Bay of Campeche	Mexico	140
1979	Trinidad &Tobago	West Indies	88.3
1992	Fergana Valley	Uzbekistan	87.7
1983	Nowruz Oil Field	Persian Gulf	80
1991	ABT Summer	Angola	80
1983	Saldanha Bay	South Africa	78.5
1978	Off Brittany	France	68.7
1988	Coast of Nova Scotia	Canada	43.04
1991	Genoa	Italy	42

The environmental awareness and standards in the 1960's compared to that of the present was relatively low and different. This led to the various degree of damage of oil production facilities resulting in the oil spillage with widespread pollution. Oil spillage is the releasing or escape of petroleum effluent to the environment, either into the waterbodies of any kind or on land, becoming harmful and contaminating or constituting pollution to the sphere **(**Chinemerem, 2015). Incidence of oil spill in Niger Delta region, in which Ogoni is located.

2.1.1 Remediation and clean-up

The initial response to oil spill incident defines a clean-up process, through the instrumentation of containment, recovery and a free phased spill oil evacuation. While a second phase response through the application of appropriate remedial technique(s) in removing the residual impact of oil contamination on soil layers or groundwater is referred to as remediation. Clean-up and remediation can go side by side simultaneously.

Oil spill incidents from oil production activities in the study area (Ogoni) was remediated by the SPDC, using a bioremediation technique known as Remediation by Enhanced Natural Attenuation (RENA). This was reviewed by UNEP after identifying some flaws as highlighted below:

I. Shallow remediation depth, which left deep seated contamination in the soil and groundwater not remediated.
II. Inadequate provision for the prevention of secondary pollution either through runoff in events of rainfall while remediation was ongoing using the land farming technique on contaminated soil.

This led to an Environmental Assessment on the entire area (Ogoniland) by UNEP and recommendations were made. An agency (HYPREP)was set up charged with the responsibility of implementing these recommendations, through the design of an effective remediation management system to a world best standard.

2.1.2 Remediation target.

Remediation is to achieve 90 percent reduction of initial level of TPH concentration, but not above 1000mg/kg, for soil with initial contamination of TPH above 3000 mg/kg. For light impacted sites, in which soil contamination is below 3000mg/kg of TPH, 50mg/kg of TPH is remediation target.

2.1.3 Remediation Techniques

Remediation management system involves various remediation approaches, classified as follows: Biological, Physical, Chemical, Thermal

These techniques can be deployed individually or in combination based on the following.

nature of contamination, degree of contamination, environmental impact, extent of contamination, engineering feasibility, type of terrain, sensitivity of the ecosystem, net benefit of environmental sustainability

2.2 Techniques used by HYPREP

Remediation approach of oil impacted sites in Ogoniland, techniques in operation.

2.2.1 Biological Technique

This involves complex hydrocarbon been broken-down simultaneously through biodegradation of contaminant, by the actions of hydrocarbon loving microbes producing water and carbon dioxide. This process is regarded as bioremediation used in the remediation of two aspects; soil contamination and groundwater, which can also be affected by some factors:

I. pH
II. RED-OX reaction potential
III. Temperature
IV. Moisture
V. Oxygen and other molecules
VI. Soil composition
VII. Solubility of pollutant

2.2.2 Contaminated Soil Remediation

This is carried out to achieve a reduction in contamination concentration within the soil, alongside some operational philosophy put in place by HYPREP in Contaminated Soil Management. Remediation of contaminated soil absolutely depends on both the chemical, physical nature of the contamination, also soil characteristics which varies according to site.

2.2.3 Basis contaminants

General hydrocarbon, straight chain aliphatic, cresols, polycyclic aromatics, phenol, semi volatile organic compound, diesel range hydrocarbon. The following technologies where considered appropriate, observing the contamination and risk.

3.0 METHODOLOGY

3.1 METHOD OF DATA COLLECTION.

Existing geographical maps, reports and technical papers related to the study area (monitoring spill remediation using GEOGRAPHICAL INFORMATION SYSTEMS) accomplished the initial studies. Some staff member of The Hydrocarbon Pollution Remediation Project (HYPREP) The agency responsible for the remediation of the study area, where key participating fully in the field investigation. Mapping a total of 64 impacted sites meant for

remedial action and a total of 12 impacted sites undergoing remediation (contaminated soil and groundwater) at various degrees.

3.2 NATURE/SOURCE OF DATA

Download of UNEP/HYPREP oil spill impacted site fact sheet was done.

The dataset for this research was sent via mail from The Hydrocarbon pollution and remediation project (HYPREP) in excel format and was downloaded and saved.

3.3 EXCEL SHEET DATABASE

The downloaded dataset was evaluated for the needed parameters and saved on a microsoft excel document(fig) as a recognisable document in an ARCGIS environment.the coordinate reference is written as Northings and Easting,WGS 84,UTM,ZONE 32N.

HYPREP

List of the impacted 64 UNEP Facts Sheets Sites and their Reference GPS Coordinates

L.G.A 1: ELEME (20 Sites)

S/No.	SITE	COMMUNITY	UNEP SITE CODE	AREA ASSESSED (ha) BY UNEP	REFERENCE GPS COORDINATES*	
					Easting	Northing
1	Ngofa -Aleto	Aleto	qc_003-002	6.80	289917	531575
2	Oboolo	Ebubu	qc_002-003	1.83	293582	527577
3	Nkeleoken	Alode	qc_002-002	32.43	291069	527211
4	Okenta	Alode	qc_002-006	0.64	292201	527740
5	Nsisioken -Agbi	Ogale	qc_001-005	67.21	292714	529480
6	Okuluebu	Ogale	qc_005-002	17.51	295231	534096

Fig 2.2: Downloaded dataset from HYPREP

A	B	C	D	E	F	G	H	I	J	K
	LIST OF SITES UNDER GOING REMEDIATION WORKS									
/NO	SITE	COMMUNITY	L.G.A	UNEP CODE	AREA DELINEATED FOR REMEDIAL ACTION (m^2)	VOLUME FOR REMEDIAL ACTION (Approx.) (m^3)	DEPTH FOR REMEDIAL ACTION (mbgs)	NO. OF CONTRA CTLOTS	LOT NUMBER(S)	
1	BUEMENE -Korokoro Well 5	Korokoro	Tai	008-003	14,048.00	59,000.00	6.10	1	LOT 016	
2	NKELEOKEN -Alode	Alode	Eleeme	002-002	48,788.00	351,300.00	8.60	6	LOT 003 TO 008	
3	OKENTA	Alode	Eleme	002-006	1,728.00	11,200.00	5.80	1	LOT 001	
4	OBOOLO	Ebubu	Eleme	002-003	7,004.00	52,000.00	10.00	1	LOT 002	
5	SAANAKO	Mogho	Gokana	019-044	7,537.00	13,000.00	2.30	1	LOT 009	
6	BARA AKPOR	Botem	Gokana	009-006	2,658.00	13,000.00	5.60	1	LOT 017	
7	WIIEBORSI	Kpean	Khana	015-003	2,674.00	14,000.00	5.40	1	LOT 015	
8	BUEMENE -Korokoro Well 9	Korokoro	Tai	008-004	2,190.00	8,100.00	3.00	1	LOT 018	
9	DEBON	Bodo/Mogho	Gokana	019-020	13,642.00	56,500.00	5.00	3	LOT 010, 011 & 012	
10	BUEMENE (Well 8)	Korokoro	Tai	008-010	10,709.00	57,700.00	6.20	2	LOT 019 & 020	
11	NWEEKOL ZORBUKE	K. Dere	Gokana	019-021	17,536.00	74,300.00	8.20	2	LOT 013 & 014	
12	AABUE/ UEKEN	Uekeni/Korokoro	Tai	008-002	1,879.00	13,100.00	6.50	1	LOT 021	
OTAL	12 Sites	10 Communitie	4 L.G.As		130,393.00	723,200.00		21 Lots	21 LOTS	

Fig 3.3: Downloaded dataset with coordinates

3.4 GEOGRAPHICAL INFORMATION SYSTEMS AS A MAPPING TOOL.

Geographical Information Systems displays geographical information from queries buffering and overlapping operation among which is the main component of Geographical Information Systems. Geographical Information Systems is widely used by decision and policy maker,managers and data analyst.the maps are used to display soil and groundwater contamination impacted area as well as remediation route.

Field investigation report has helped ascertain the various extent of contamination, and the impact on management decision through the use of Geographical Information Systems. basically, the equipment used where all standard mapping kits including Geographic Positioning System (GPS)

3.5 VIABILTY/REALIABILITY OF INSTRUMENT

Table 3.1: Showing list of software used for data analysis

SOFTWARE	USES

ESRI ArcGEOGRAPHICAL INFORMATION SYSTEMS	Cartography,digitization,geocoding
ESRI Spatial Analyst	ESRI Spatial Analyst
Google Earth/Google Earth PRO	Data visualization
Suffer	Contour Modelling

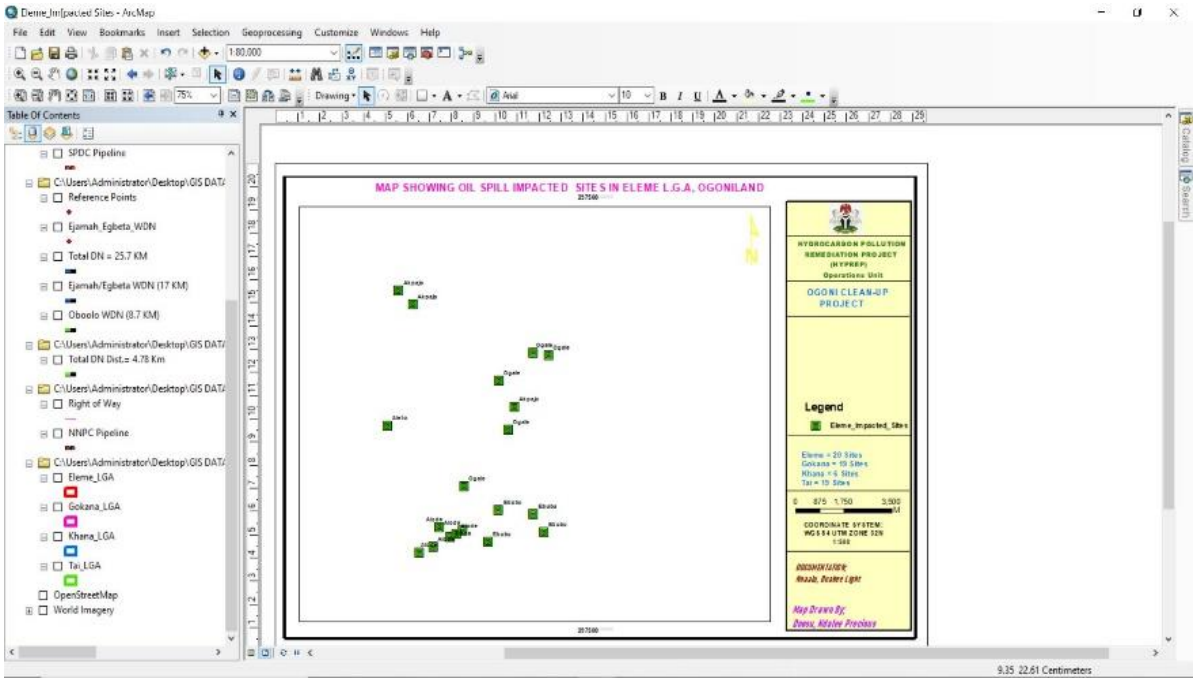

Figure 3.4: Displayed data attribute added as theme in view

4. 0 RESULT AND DISCUSSION

4.1 Research and Analysis

Social-economic and environmental impact of spill makes Remediation a serious issue of concern. Therefore, a proper remediation must be done for the Restoration of the ecosystem. Monitoring the Remediation of spill impacted site requires adequate knowledge of contamination at various sites/area. The approach first identified the primary direction of spill migration and carry out cross-sectional transects covering the polluted area**.**

Local government by local government impact site analysis

4.2 ELEME

According to the HYPREP fact sheet, there is a total of 20 contamination impacted sites. Spread across the local government.

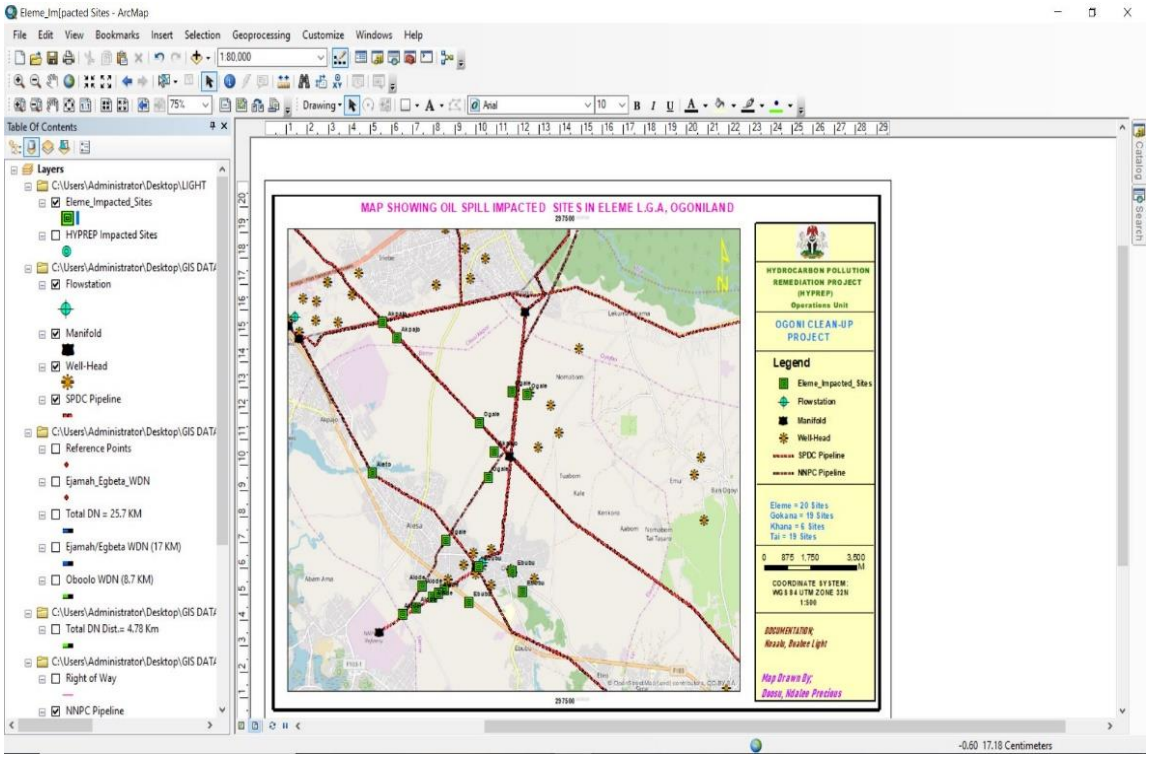

Fig 4.9: Map showing 20 oil impacted site in Eleme LGA, displayed in ArcGIS environment

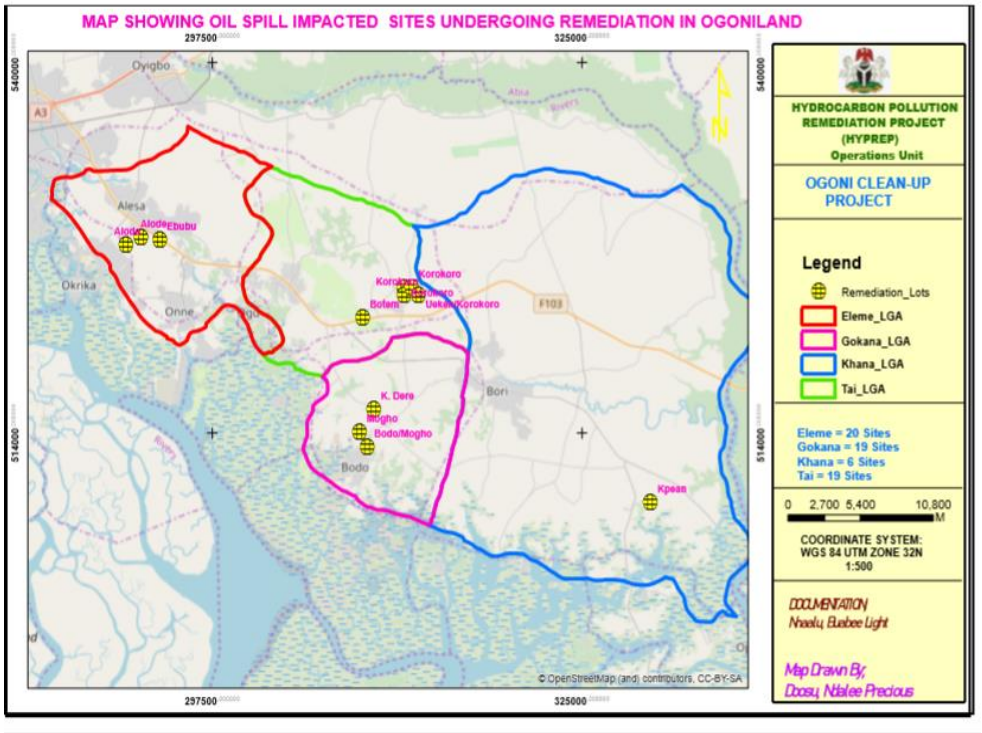

Fig 4.10: Map view of impacted sites undergoing remediation

4.3 TAI LGA

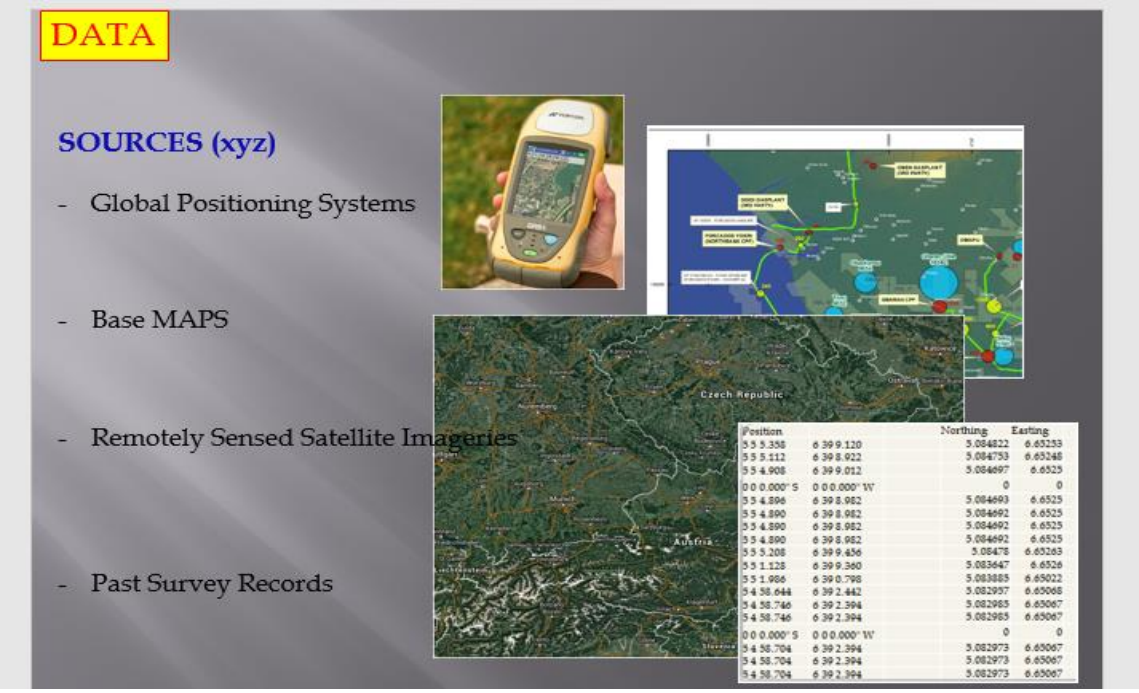

Fig 4.11: Instrument used in acquiring coordinate

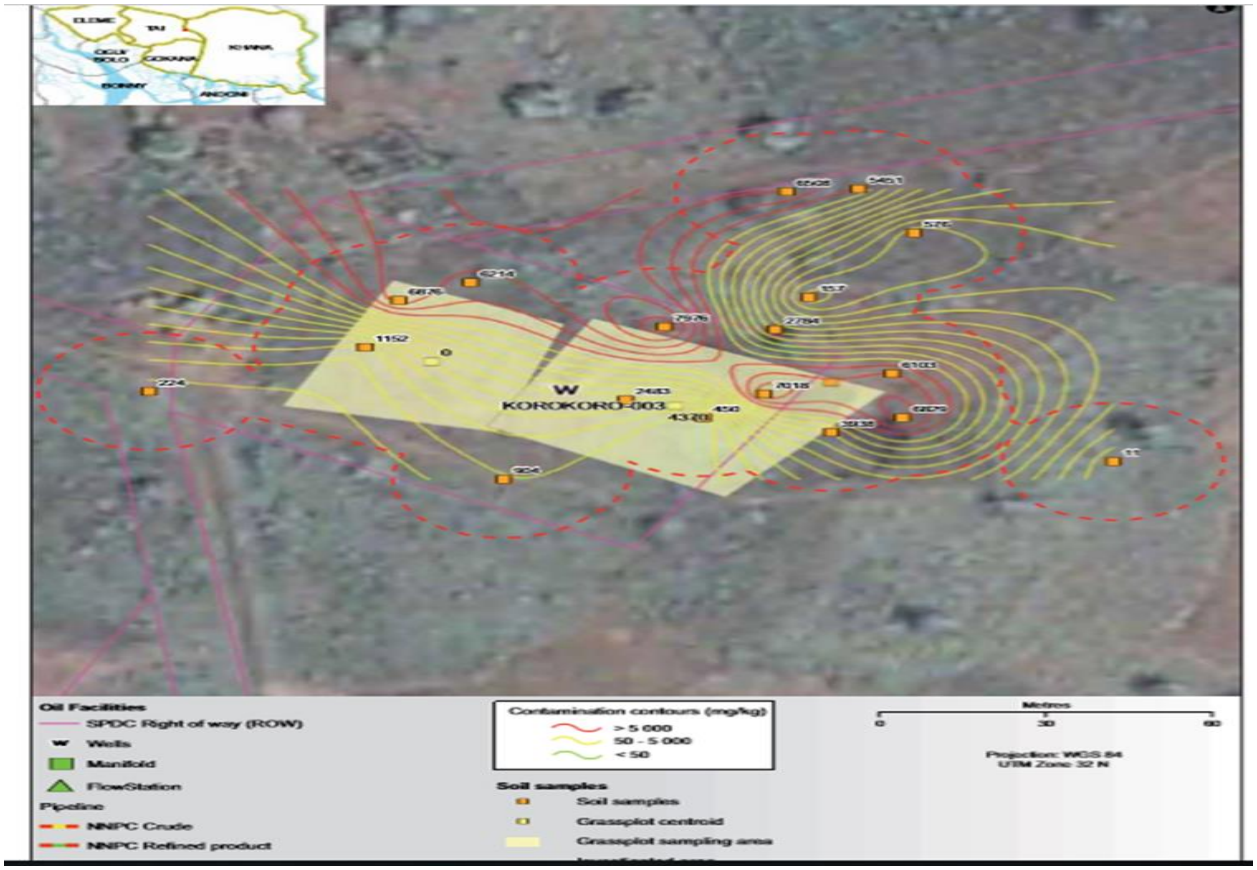

Fig. 4.5: Contamination contour at korokoro Tai LGA

4.4 GOKHANA LGA

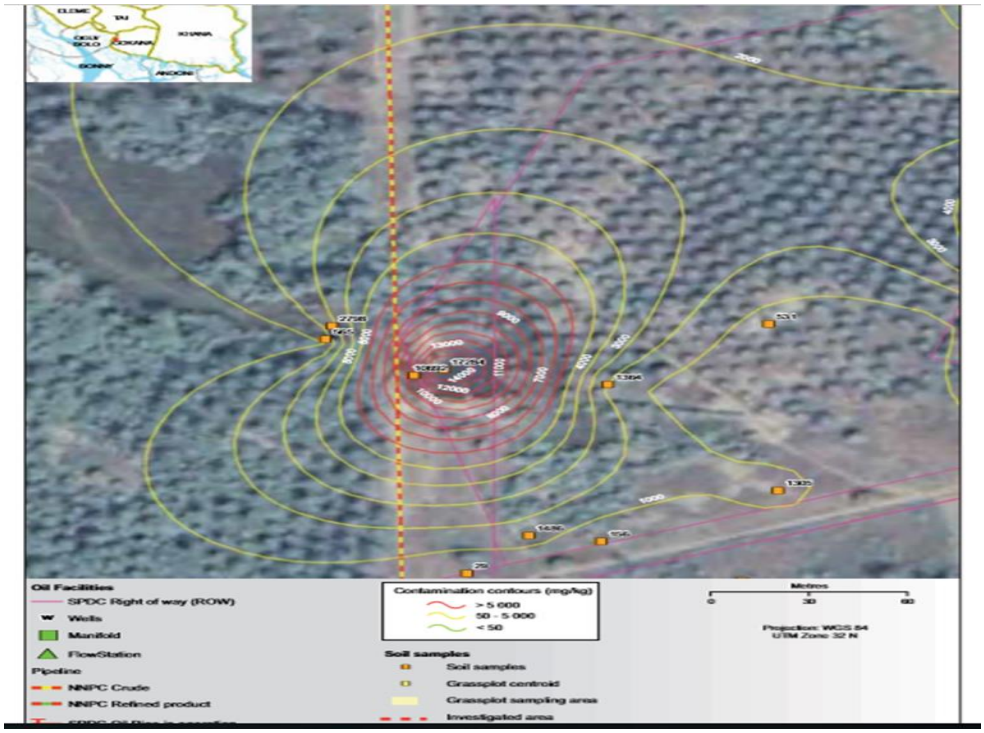

Figure **Error! No text of specified style in document.**.6: Map showing contamination contour of k Dere in Gokhana

5.0 SUMMARY AND CONCLUSION

The accomplishment of this Research was made possible through the provision of the: oil spill contamination impact data, primary spill source data with their respective coordinate reference system as contained in the UNEP fact sheet provided by HYPREP.

These data were analysed using the technology of Geographic Information system (GIS), digitizing only the interest area inputted to digital environment. Designating output as a representative of various degree of contamination impact as represented by the maps and contours. This maps and contours are used as a guide in decision making as to what remediation techniques can be applicable to the various impacted sites as the case may be. Pictorial view of spill sources and impacted area as indicated in maps, contributes in proposing a good Remediation Management System (RMS) aimed at environmental restoration. The Geographic

Positioning System (GPS) coordinates of 64 impacted sites around study area and 12 amongst which Remediation is ongoing was imported into the ArcGIS(Software).

From chapter four, the result shows that the impact of spill close to the flow station, manifold, wellhead and pipeline cannot be the same when compared to those far apart which might have been due to spreading. This also affect the Remediation technique at those various points.

Furthermore, the contour maps display the spread pattern of contaminants, which is key during a Remedial Action (e.g. fig indicates the spill source to be NNPC crude pipeline, point of major impact or occurrence making contamination level to be 77284mg/kg spreading, decreasing the contamination level towards 10692mg/kg to the least point of 29mg/kg). (UNEP report on ogoni,2011)

This research work is believed to serve as a reference point in monitoring oil spill Remediation through the use of technology like the Geographical Information Systems and subsequent improvement in achieving the aim of Remediation within the Niger Delta.

6.0 RECOMMENDATION

Geographical Information Systems is key in environmental study, especially in Remediation Management System (monitoring of oil spill Remediation and management as detailed in this report). This makes the study interesting and should be shown much concern by the higher institution of learning, government, regulatory agencies of the environment (like the DPR, Federal, State and Local Ministries of Environment, NGOs, CBOs and host communities) Multinational Companies, Oil operators (both indigenous and foreign), oil stakeholders, integrating Geographical Information Systems in oil spill and Remediation Monitoring.

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